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# ENGINEERING GRAPHICS

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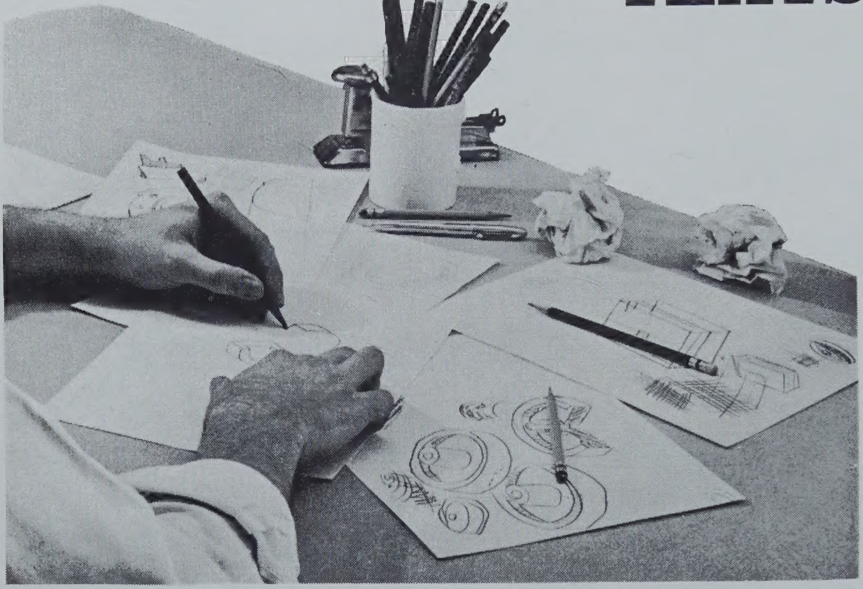

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*GREETINGS: To the new editor, greetings and best wishes. To all friends in the Society, so long for awhile. I will be unable to attend the annual meeting because of work out west. Thank you for the opportunity to serve the past three years. See you in Wisconsin.

## DRAFTSMEN ARE COMMUNICATORS

In a corporation, detailers, layout men, and designers work with the engineers in each development group. Without these men on the drawing boards there would be no engineering accomplishments.

The vital role of these men in the engineering program is emphasized by Charles A. Chayne, Vice President of General Motors. In a statement to educators and professional men in engineering, Mr. Chayne has said: "Drafting is probably the engineer's most important form of communication. Just as picture-writing, the first form of written communication, was used to express thoughts and records, so do engineers working with graphics mold intangible ideas and theories into tangible goods and products. The real creative engineering is done in the drafting room, and there must be a design before there can be a test or experimental program."

In order to be successful in our competitive market, an engineering product must be functional; it should be simple, compact, low in cost, light in weight and trouble-free. The refinement of a design to its simplest and most economical form is accomplished by graphical study on the drawing board.

Using the language of his profession, engineering drawing, the designer evolves the engineer's abstract idea into tangible and practical form. During this evolution, problems will be discovered, alternate arrangements visualized, and other areas of investigation indicated and pursued by designer and layout man, until eventually the optimum design is reached. Finally, detail and assembly drawings must be made to convey all information necessary for manufacture of the product.

An artist strives to produce a picture by lines, shading and color: he may only suggest his meaning. The engineer has a greater task. Rather than suggest, he must give exact and positive information on the machine or structure existing in his mind. To the engineer, engineering drawing is more than a pictorial representation; it is a complete graphical language.

The above article is from Autogineer, Employe publication of GM Engineering Staff, January, 1961. Our Cover photograph shows some of these men at work.

Editorial

## RELATIVITY AND RE-EVALUATION

In Engineering Education, the relativity of one part to others must be weighed and adjusted.

After years of argument, socio-humanistic subjects have moved into engineering curricula. In reasoning for these subjects, were established engineering subjects irrationally devalued? Rather than add socio-humanities and thus extend the undergraduate program to four and one-half or five years, most colleges have provided for these new subjects by deleting or reducing time for historically proven engineering subjects. Although they are of continuing or increased importance, certain professional engineering courses have been sacrificed for a melange of sociology, art, philosophy, more English and various life-adjustment electives.

U. S. colleges of engineering are producing a better-adjusted (happy) graduate with less technical knowledge. Has the philosophy of life-adjustment been carried too far? Should pursuit of happiness, security and pleasing personality displace necessary and practical learning in engineering disciplines?

Examine the relativity of one part of engineering, engineering drawing (drawing, descriptive geometry, nomography, axonometry, etc.) to one of the socio-humanistic subjects which have displaced engineering drawing, English (rhetoric, composition, exposition, speech, verbal communication, oral interpretation, literature, drama, etc.).

Engineering drawing is a new science to the engineering freshman, a new kind of mathematics and communication. As have all engineering concepts, drawing has become more complex. In Europe, descriptive geometry is taught in the department of Mathematics and Descriptive Geometry; while the subject has been dropped in the U. S. to make room for non-engineering subjects, descriptive geometry maintains high respect in European engineering curricula.

Formerly, engineering drawing was allowed as much time or more than English in engineering curricula. Now, in spite of the enlarged scope of the subject, engineering drawing has been cut down to three or four credits in many colleges, or nearly eliminated in others. Such limited drawing courses give the student competence in drawing simple blocks and other elementary knowledge. Few universities confront the engineering freshman with formidable courses in drawing. On the other hand, college English requirements in various forms have been amplified to twelve credits or more for the engineering student.

A college-calibre intellect should achieve competence in the English language after seventeen years of use and twelve years of fair pre-college instruction. If the quality of a student's learning is adequate year-by-year, then a thirteenth or fourteenth year of English (in college) should make little improvement on the proficiency gained in twelve years.

In Russia, learning the Russian language is accomplished in the ten years preceding college. No valuable college time is lost educating Russian engineers in academic courses on writing, reading or speaking Russian! It is also noteworthy that many Russian students entering college have some facility with the English language as well!

Is the American student so inferior that he cannot properly prepare himself in his native language in the twelve years before college entrance From grades 1 to 14 inclusive, our engineering student must have some form of English; yet, he is supposedly brighter than average. This requirement disregards the relativity of English ability to abilities in other critical areas.

In relativity, the engineering student learns but a trifle of engineering drawing and descriptive geometry. Often he receives but a short exposure to the geometry, calculations and nomography (mathematics), the complex standards, and the communication of engineering drawing in a one-semester course! It is now a decision-in-being in American universities to overcome deficient ability in the mother-tongue, English, rather than assure reasonable competence in engineering drawing for our engineers! If one could imagine English instruction in the student's lifetime so meager as that allotted to engineering drawing, the student would learn a few letters of the alphabet, the spelling, sounding and meaning of a hundred words or so, and the manual-mental skills of sentences such as "I see the black dog."

Is it a fitting task for a university to remedy the inadequacy of pre-college teaching of English? Rather, the university might well offer remedial non-credit courses in English for those who cannot prepare themselves in the twelve years before they approach the college door. College students preparing to teach English in elementary and secondary schools should concentrate on English and literature courses, and less on courses in educational theory and philosophy. With better-equipped teachers of English, twelve years of the subject should be more than enough. Our young people are not entirely at fault in learning less of their language in twelve years than European children learn in ten.

After these years of implementation of "The Evaluation of Engineering Education" it is now prope to examine the results of this experiment and to re-evaluate engineering education. In such re-appraisa practicing engineers should have some voice as well as the professors. Perhaps improper relativity has been effected between "life-adjustment" subjects and certain engineering fundamentals which are now slighted or omitted. Socio-humanities are learned by living, in the home, the family, community and church; the classroom is a poor laboratory.

We should restore to an adequate level certain engineering subjects which have been sacrificed to make room for socio-humanistic subjects which are remedial (such as English), which can be readily learned by extra-curricular reading and activity, or which principally derive from life-experience.

# APPLICATION OF GRAPHICS AND NOMOGRAPHY TO HEAT TRANSFER STUDIES

By Wickliffe B. Hendry

Westinghouse Electric Corporation
Aviation Gas Turbine Division

Graphics is used extensively in heat transfer studies to encompass a great diversity of applications. The diversity of applications is best indicated, perhaps, by considering two aspects of heat transfer studies. First, heat transfer may occur by conduction, convection, or radiation. Second, heat transfer studies follow a general pattern which is typical of most engineering studies.

The applications of graphics vary to a marked degree with the mechanism of heat transfer under study. Applications in conduction, for example, include the graphical solutions to problems as well as the graphical presentation of quite difficult analytical solutions. Applications in convection pertain to the graphical presentation of data such as nomographs for fluid properties, graphs of heat transfer surface characteristics, and graphical solutions to problems. Typical applications in radiation include the graphical determination and presentation of the view factor for various geometrical configurations.

The applications of graphics also vary greatly with the different stages of a study. For example, heat transfer studies follow a general pattern which consists of a series of steps. The first step is a statement of the problem. Subsequent steps are preparation of the problem for solution, solution, interpretation of the results, and presentation of the conclusions with appropriate recommendations.

Let us now look at some illustrative examples of graphics in heat transfer studies. These examples are arranged in three groups. The first group, consisting of figures 1 through 3, shows typical graphical solutions of a transient-state, heat conduction problem. The second group, consisting of figures 4 through 12, traces the design of a cross-flow, heat-exchanger core from the original statement of duty requirements to the final design. The last group, consisting of figures 13 and 14, is a graphical presentation of results from recent studies of radiators for powerplants to operate in space.

## Graphicsl Solution of Transient-State Heat Conduction Problem

Figure 1 shows a slab of steel initially at a uniform temperature of $t_0$°F. The right-hand face is bounded by an adiabatic wall. At time zero a fluid is suddenly brought into contact with the left-hand face. It is desired to know the subsequent temperature-time history in the slab as well as the total energy which has flowed from the slab to the fluid at any subsequent time.

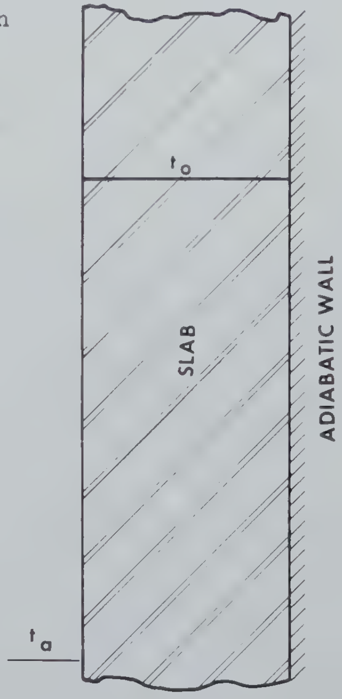


FIGURE 1. SLAB WITH SURFACE QUENCHING

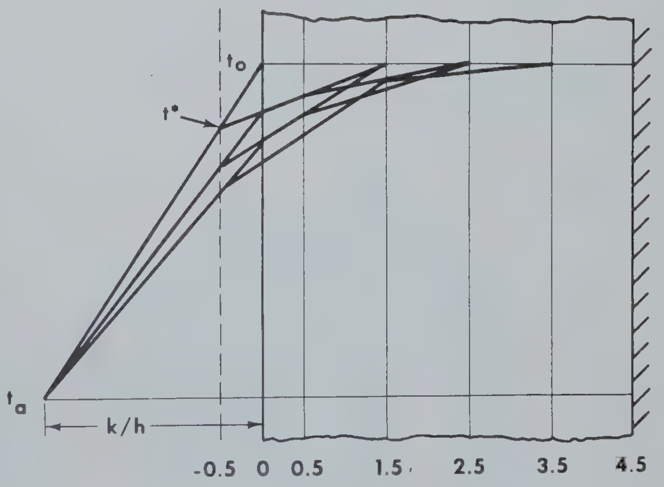


FIGURE 2. SCHMIDT'S GRAPHICAL METHOD

Figure 2 shows a graphical procedure for determining the temperature time history in the slab. This particular technique is Schmidt's graphical method and is discussed at length in various heat transfer texts. Note that this method also shows the temperature gradient at the left boundary of the slab, as well as at interior points. This temperature gradient permits the heat flux density across the left face of the slab to be expressed as a function of time as shown in figure 3. Thus, the total energy which has flowed from the slab to the surrounding fluid in time $t_1$ is represented by the area under the curve in figure 3.

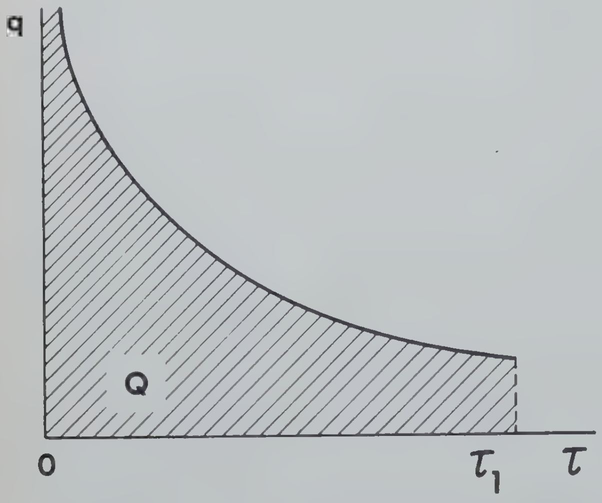


FIGURE 3. HEAT FLUX DENSITY VS TIME

Design of a Cross-Flow, Heat Exchanger Core

Figure 4 is a simple sketch of a cross-flow, heat-exchanger core for a certain application. As may be noted two fluids flow through the core. Fluid 1 flows through the tubes from back to front, while fluid 2 flows across the tubes from bottom to top. Energy is transferred by convection from the high temperature fluid into the tube walls. This energy then flows by conduction across the tube walls and thence by convection into the low temperature fluid.

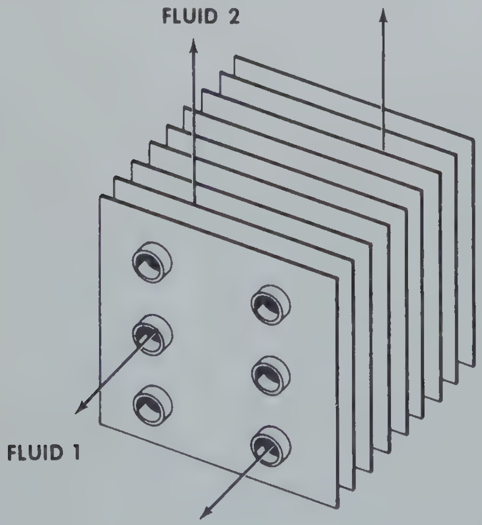


FIGURE 4. CROSSFLOW HEAT EXCHANGER CORE

The problem statement usually includes the fluid flow rates, fluid states at inlet to the heat-exchang desired performance, and various limitations on over all geometry. The solution specifies the surface geometries; i. e., it describes the tube diameter, tube spacing, fin spacing, fin height, fin thickness, and other related dimensions. The solution also specifies the over all dimensions of the heat-exchanger core.

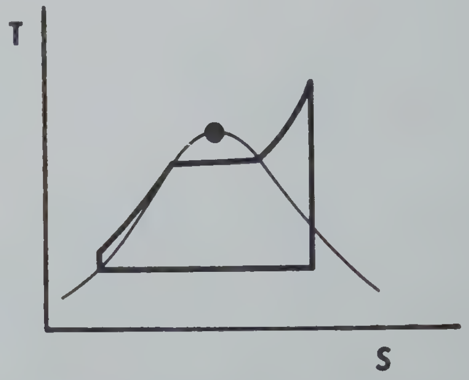


FIGURE 5. TEMPERATURE-ENTROPY DIAGRAM FOR WAT

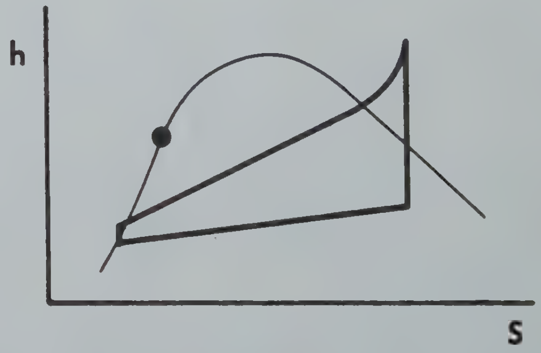


FIGURE 6. ENTHALPY-ENTROPY DIAGRAM FOR WATER

The first step in the solution of this problem is to determine the fluid states at exit from the heat exchanger. One of the more conventional graphical aids used for this purpose is the temperature-entropy diagram, figure 5. As you may note, an ideal Rankine cycle with superheat is shown in the heavy lines while the vapor dome is indicated by the light line. The critical point is indicated by the heavy black dot. There are four heat exchangers in this cycle: (1) feedwater heater, (2) boiler, (3) superheater, and (4) condenser. This graphical aid thus enables one to immediately identify all fluid states in which he may be interested.

Another common graphical aid used for a similar purpose is the familiar Mollier diagram shown in figure 6. Again the Rankine cycle with superheat is shown by the heavy lines, the vapor dome is shown by the light line, and the critical point by the dot.

The second step in the solution of this problem is to determine the various fluid properties required for establishing the heat flux density. Figure 7 is a nomograph showing the specific heat of Dowtherm A as a function of temperature. One of the big advantages of this nomograph is that the specific heats of many fluids can be shown on only one page by using a variety of reference points. Only one point is shown on this particular figure for clarity.

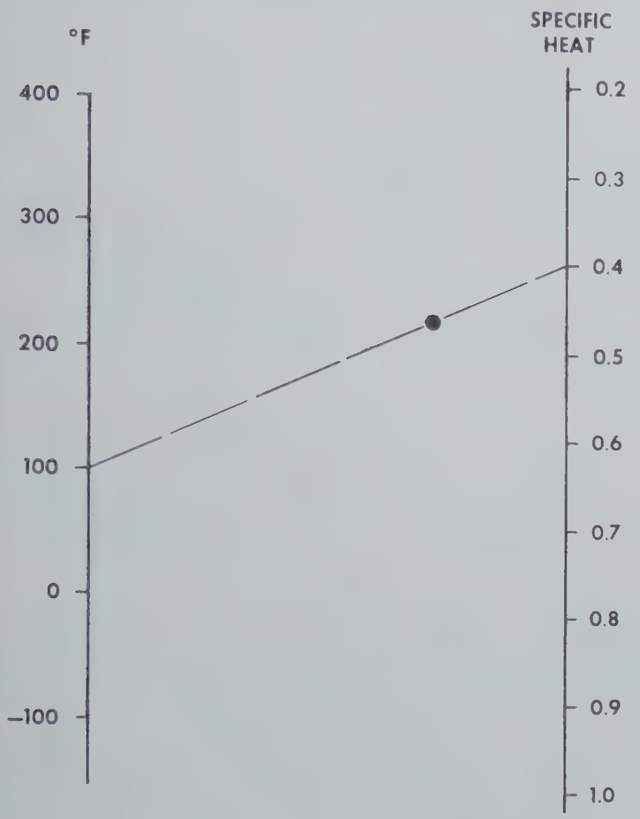


FIGURE 7. SPECIFIC HEAT OF DOWTHERM A

Another fluid property required for the calculations is viscosity. Figure 8 is another nomograph, similar to figure 7 except that viscosity is the right hand scale and the appropriate reference point is located by stating the proper grids (x,y).

Figure 9 is another nomograph expressing another heat transfer parameter, the Prandtl number as a function of temperature.

One continues in this fashion until all of the necessary fluid properties are known for both heat transfer fluids.

The third step in the solution is to determine the proper heat-transfer surface geometries. This is a rather nebulous and difficult aspect of the procedure; therefore, let us assume that the surfaces are known. There are certain surface parameters which are ordinarily presented graphically as shown in figure 10. One of these parameters is the dimensionless friction factor, f, with which you are probably familiar. It is used to determine pressure loss across the heat exchanger core. The other parameter is the dimensionless heat transfer factor, j, used for determining the heat flux density. Both the heat transfer factor, j, and the friction factor, f, are expressed as a function of the Reynolds number, Re. Two such graphs are required for the heat exchanger core: One for the inside of the tubes and one for the finned side of the tubes.

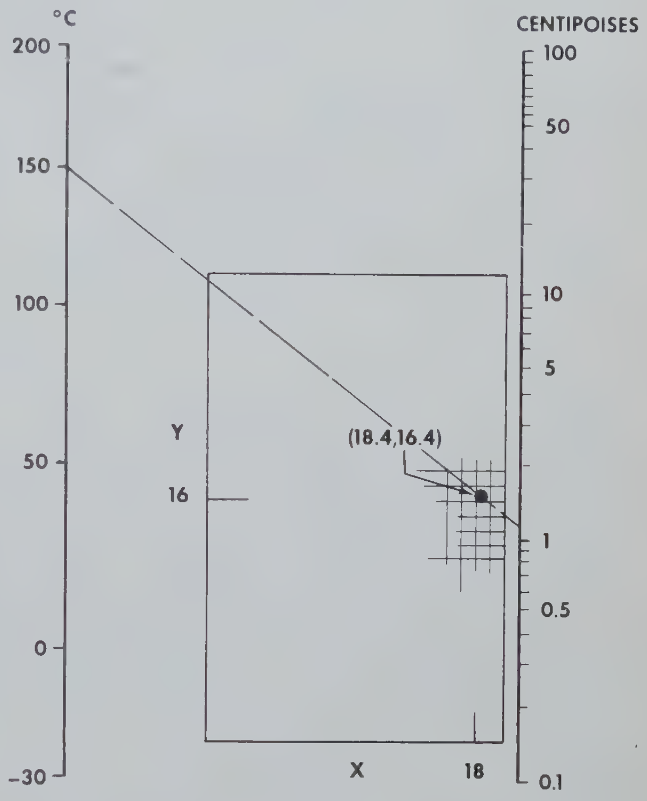


FIGURE 8. VISCOSITY OF MERCURY

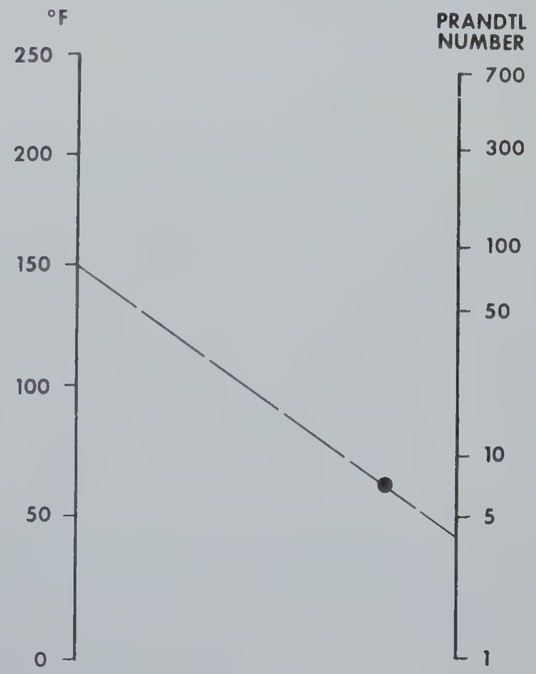


FIGURE 9. PRANDTL NUMBER FOR WATER

The fourth step in the solution is to solve a system of about 17 equations which include all of the necessary relations. In some of our earlier work on this problem, the 17 equations were reduced to one such as is shown in figure 11. As you may note f (Re) is a double-valued function. Only one of the roots is a solution to our problem, of course. This, plus some other undesirable characteristics of the curve caused us to run into difficulties with the digital computing machinery used to solve the equation. This graphical presentation of the function, with values taken from the computer print-out, was invaluable in helping to direct the computer to a successful closure on the proper root.

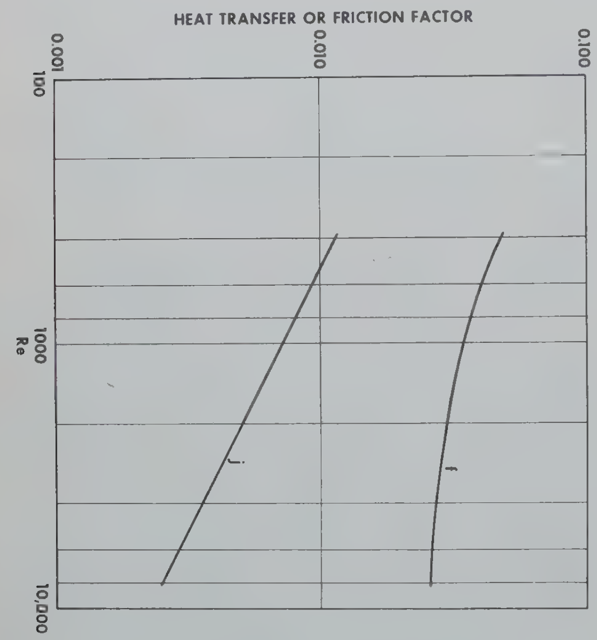


FIGURE 10. HEAT TRANSFER AND FRICTION FACTORS FOR FIN AND TUBE SURFACE

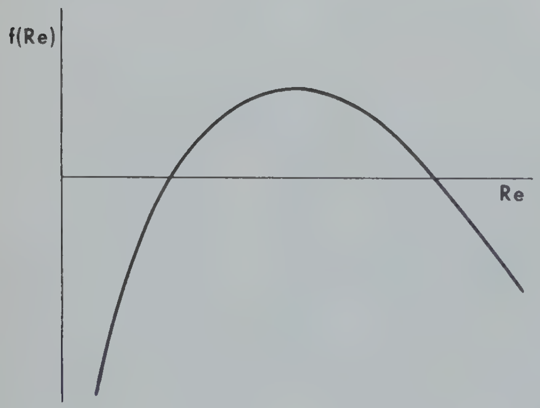


FIGURE 11. SOLUTION OF CROSSFLOW HEAT EXCHANGER PROBLEM

We have since reworked this problem by a much more thorough analytical study. The present solution is shown in figure 12, in which the abscissa is a function g(Re) and the ordinate is a function h(Re). As you may note the function is single-valued within the domain of g(Re) between zero and 1. Thus, the solution is unique and straightforward.

The last step in our problem, now that one of the unknowns has been determined is to evaluate each of the other 16 unknowns in a systematic manner.

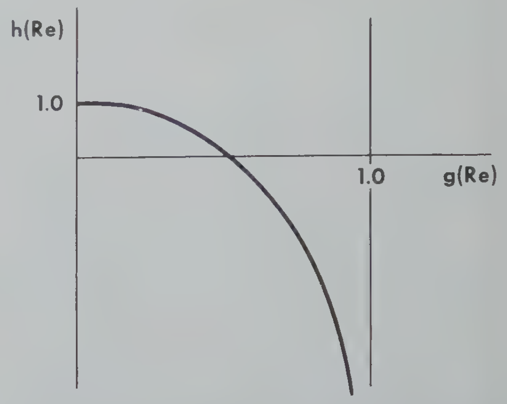


FIGURE 12. SOLUTION OF CROSSFLOW HEAT EXCHANGER PROBLEM

## Radiators for Space Aircraft

There is considerable activity at the present time in the study of radiators for space craft. These radiators are expected to meet a number of requirements in addition to those imposed on conventional heat exchangers. Some of these requirements are resistance to meteoroid penetration, minimum mass, and operation in a no gravity field.

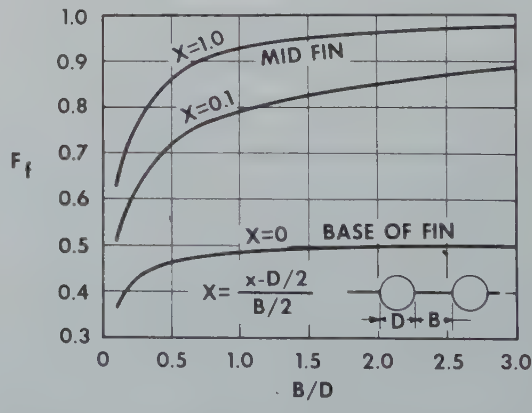
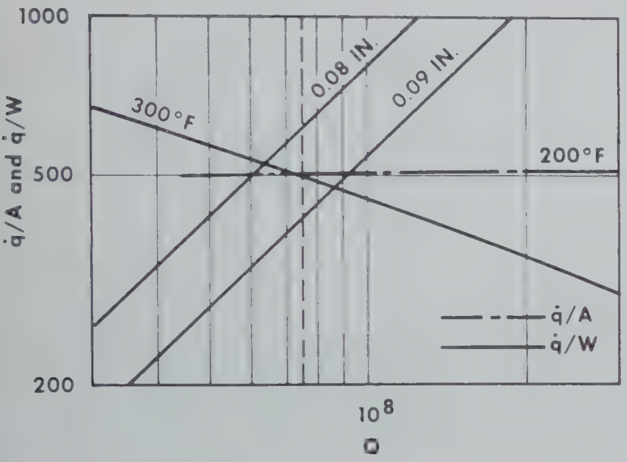


FIGURE 13. FIN VIEW FACTOR VERSUS B/D

Figure 13 is taken from a paper by J. P. Callinan and W. P. Berggren, "Some Radiator Design Criteria for Space Vehicles", Trans. ASME, Journal of Heat Transfer, Vol. 81, C, No. 3, August 59. It pertains to a fin and tube heat exchanger as shown by the sketch in the lower right hand corner. The abscissa is the ratio of fin height to tube diameter, B/D, and the ordinate is the view factor, $F_f$, for elements of fin surface area. The parameter X is merely a dimensionless presentation of position along the fin height.

The significance of this graph stems from the fact that space radiators reject energy by radiation only. Thus, each element of fin area should have the maximum possible view of low temperature space. That is, the fins should not see the tube walls. As shown by the parameter X = 1.0, the fin view factor is highest at the midpoint between tube centerlines. The highest view factor for all elements of fin area is achieved, of course, by choosing the largest possible value of B/D.



IGURE 14. WASTE HEAT RADIATOR CHARACTERISTICS

Figure 14 is another example of the applications of graphics to space radiators. The abscissa, Q, is the total heat load with which the radiator is expected to dissipate during its lifetime. The ordinate represents two different quantities: The time rate at which energy is rejected for a unit area of radiator surface, $\dot{q}/A$, and the time rate at which energy is rejected for a unit mass of the radiator, $\dot{q}/W$. A problem example will assist in explanation of the graph:

The required value of Q is known as indicated by the vertical broken line. The radiating temperature is 200°F. Choosing the dot-dash line, as shown in the legend, we note that $\dot{q}/A$ is about 500. Similarly, $\dot{q}/W$ is about 500 for a radiating temperature of 300°F. The required tube wall thickness for the specified life of the radiator is shown by the third parameter to be about 0.082 inch for a radiating temperature of 300°F.

## Summary

Graphics is used extensively in heat transfer studies to encompass a great diversity of applications. Some examples of these applications have been presented for heat transfer by conduction, convection, and radiation. Other examples have shown the use of graphics for recording fluid properties, as an aid to numerical computations with digital machinery, and for presenting the results of complex analytical studies. Lastly, it is shown that as heat transfer studies expand into new areas there is an ever increasing demand for the applications of graphics.

ENGINEERING GRAPHICS DIVISION OF ASEE - ANNUAL MEETING

UNIVERSITY OF KENTUCKY - LEXINGTON, KENTUCKY

JUNE 26-30, 1961

## ENGINEERING GRAPHICS DIVISION

## OF

## THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

## ANNUAL MEETING

UNIVERSITY OF KENTUCKY
Lexington, Kentucky

June 26 to 30, 1961

- PROGRAM -

Monday - June 26

6:30 p.m.
Executive Committee Dinner and Business Meeting (Current and newly elected members and guests). Presiding: Irwin Wladaver, NYU

Tuesday - June 27

12:00 Noon
Annual business meeting
Presiding: Irwin Wladaver, NYU

2:00 p.m.
Joint meeting of the Divisions of Technical Institutes and Engineering Graphics
Theme: Visual Communication
Presiding: E. W. Jacunski, U. of Florida

1. Philosophy of Visual Communications. B. V. Schultz, Market Research, The Tecnifax Corp., Holyoke, Mass.
2. Devices in Visual Communications:
   In Engineering Graphics,
   L. O. Johnson, NYU
   In Descriptive Geometry,
   R. B. Thornhill, Wayne State U.
   In Graphical Communications,
   W. B. Rogers, U. S. Military Academy
   In the Technical Institute,
   R. J. Young, Wentworth Institute
3. Recent Developments in Methods of Reproduction. Albert Prioletta, Port of New York Authority, New York, N. Y.

7:00 p.m.
Workshop in Visual Communications.
Presiding: Mary F. Blade, The Cooper Union.
Staff: B. V. Schultz, Market Research, Tecnifax Corp., Holyoke, Mass.
Sheldon Dunlap, Cincinnati Branch Manager, Tecnifax Corp., Cincinnati, Ohio

Wednesday - June 28

12:00 Noon
Joint Luncheon of the Divisions of: Aeronautical Engineering, Educational Methods, Engineering Economy, Engineering Graphics, Evening Engineering Education, Industrial Engineering, Mechanics, Nuclear Committee, Textile Engineering

Theme: An American Company Operating in Underdeveloped Nations.
Presiding: N. N. Barish, NYU
Speaker: F. E. Larkin, W. R. Grace and Co., 7 Hanover Square, New York, N. Y.

2:00 p.m.
Joint Meeting of the Divisions of: Agricultural Engineering, Architectural Engineering, Civil Engineering (Committee #1), Educational Methods, Electrical Engineering, Engineering Graphics, Engineering School Libraries, English, Evening Engineering Educatio
Humanities and Social Sciences, Mechanics, Physi

Theme: The Birth of a Book - The Mutual Responsibilities of Publishers and Authors.

Presiding: Irwin Wladaver, NYU.
Moderator: B. R. Teare, Jr., Carnegie Institute of Technology

Publishers' Panel: R. F. Bitner, Assistant Vice President, Prentice Hall, Inc., Englewood Cliffs N. J.
C. L. Skelley, Editorial Consultant, Holt, Rinehart & Winston, 383 Madison Ave., New York, N. Y
C. B. Stoll, Editor, John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.
K. I. Zeigler, Editor-in-chief, College Dept., McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y.

Authors' Panel:
P. F. Chenea, Purdue U.
H. A. Foecke, U. of Notre Dame
Archie Higdon, U. S. Air Force Academy
J. W. Souther, U. of Washington
B. L. Wellman, Worcester Polytechnic Institute

6:30 p.m.
ANNUAL DINNER
Presiding: Irwin Wladaver, NYU
Speaker: Mr. Penrose Ecton, Lexington, Kentucky

Thursday - June 29

9:00 a.m.
Conference
Theme: Engineering Graphics in Transition
Presiding: J. S. Dobrovolny, U. of Illinois

1. Advanced Drafting in Senior High Schools, R. L. Barton, the Texas Education Agency
2. Foundations in Graphics Through Industrial Arts, Paul DeVore, State U. of N.Y., Oswego
3. Educational Relations and the Division of Engineering Graphics, Gustav Rook, Northeastern U.

* * * * * * * * * * * * *

STUDENT WORK AND QUIZZES DISPLAY - ASEE

Annual Meeting - Engineering Graphics Division

University of Kentucky
June 26-30, 1961

The committee is eager to have on hand at Kentucky an outstanding display of student work and quizzes for examination by Graphics Division members. Every year new instructors join our ranks. This group of newcomers as well as all veteran instructors can find something of value in the annual display. This year we would particularly like to have on display:

1. Material used in graduate or undergraduate courses in advanced graphics.

2. Materials from courses particularly designed for special curricula (i. e., Graphics for Electrical Engineers, Geology Majors, etc.)

3. Student work and quizzes from Engineering Graphics courses of all types.

4. Examples of courses taught for non-degree programs in drafting or graphics.

5. Interest has been indicated in the display of models or other devices used in the presentation of course material.

To facilitate handling and prevent possible loss, display material should be in bound or assembled form. The exhibitor should transport it to Kentucky. However, packages may be sent postpaid to Professor Hoffman, Engineering Drawing Department, University of Kentucky, Lexington, Kentucky.

Please include a statement on or inside the cover indicating the number of hours per week, credits and other pertinent data.

Co-Chairmen: C. K. Hoffman, U. of Kentucky
E. T. Ratledge, U. of Wisconsin (Milwaukee)

1:30 p.m. Group Picture

2:00 p.m.
Conference
Theme: Engineering Graphics for Modern Engineering
Presiding: S. A. Coons, M. I. T.

1. Correlating Graphics with Basic Engineering Sciences, P. M. Reinhard, U. of Detroit
2. Graphics—A First Design Course, J. B. Reswick, Case Inst. of Technology
3. A Few Areas Where Better Use of Graphics Would Improve Communication, J. W. McCutchan, U. of California, L. A.

* * * * * * * * * * * * *

NOMOGRAPHY AWARD

The annual award of $100.00 for the best engineering nomograph published between January 1, 1960 and December 31, 1960 will be presented at the Annual Meeting of A.S.E.E., June, 1961. This award for the Fifth Nomography Competition was generously donated by the International Harvester Company.

Richard G. Huzarski
Chairman
Nomography Committee

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# THE FUNCTION OF GRAPHIC AND ILLUSTRATIVE LANGUAGES IN THE COMMUNICATION PROCESS

By Robert A. Sencer

Rensselaer Polytechnic Institute

In the curriculum for the master's degree in technical writing is the course, Methods of Presentation. This explores the cooperative function of the verbal and non-verbal languages in technical writing. People in technical communications should let people in engineering drawing know of their ideas and principles, and should solicit the criticisms of engineering drawing people about these ideas.

The title of this paper contains the phrase graphic and illustrative languages. The paper contains the phrases non-verbal languages and engineering drawing. These phrases should be considered somewhat synonymous.

A basic principle in consideration of technical writing, whether as a prime skill of the professional technical writer or as an auxiliary skill of the engineer or scientist, is that the person who writes must exert a good deal of cooperative effort between verbalization and drawing. To do this, the writer must recognize the functions and the limitations of both these languages. Each language has its own functions and its own limitations, and it is the proper recognition and use of these that leads to the utmost efficiency in the communication process, especially in technology.

First, the function of the verbal language will be outlined. It might be described simply as this: to act as a vehicle carrying information from one person, the writer, to another person, the reader. To be successful, the writer must see that his vehicle carries this information correctly, concisely, and therefore efficiently. To accomplish this function, verbal language uses certain abstract symbols in quite a number of ways: as names of things (nouns and pronouns), as names of actions and states of being (verbs), as qualitative and quantitative statements (adjectives and adverbs), and as statements of relationships (prepositions and conjunctions).

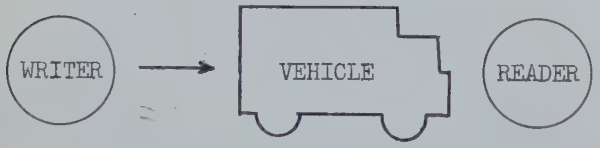

Fig. 1. A Writer-Reader Information Flow Diagram (An Over-Simplification of Communication)

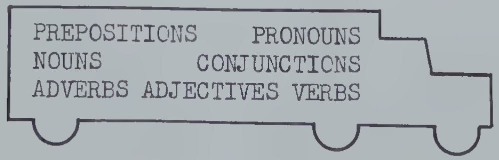

Fig. 2. The Communication Vehicle

To continue to accomplish its function, verbal language has to have structure. This structure is one of a single dimension; it is linear. Its basic structural principle is Time, or chronology.

In Figure 3, three rather common symbols have been arranged in a completely random order. In looking at such an array, anyone would have to admit that no information is being transmitted.

LIKES MARY LIKES
LIKES
JACK JACK
JACK MARY MARY

Fig. 3. Random Distribution of Verbal Symbols

If, however, the symbols are arranged in a time sequence--that is, with one symbol following another--some progress toward communication is achieved. Figure 4 shows several possibilities, some of which still make no sense, others comprehensible sense.

LIKES MARY JACK
JACK MARY LIKES
MARY JACK LIKES
JACK LIKES MARY
MARY LIKES JACK
LIKES JACK MARY

Fig. 4. Verbal Symbols Arranged in Several Time Sequences.

And finally, verbal language has several kinds of organization, none of which lends itself readily to a non-verbal analogy. These various organizations result in written communication which we call description, narration, persuasion, and direction an instruction. (There are a number of other kinds of organization, used primarily in fiction, which do not concern this paper.)

Now the function of the non-verbal language will be outlined. This language, the graphic and illustr tive language, engineering drawing, has a primary function, exactly the same as that of the verbal language; to act as the vehicle carrying informatio from one person, the writer, the draftsman, the engineer, to another person, the reader.

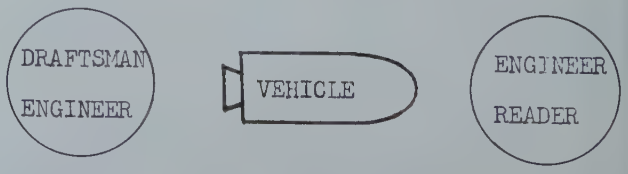

Fig. 5. An Engineer-Reader Information Flow Diagra

To accomplish this function, the non-verbal language uses realistic symbols, generally, rather than abstract symbols as does the verbal language. That is to say, the non-verbal language uses, not the real thing itself, but an approximate, visual representation of it. The most realistic representation is the scale model; then the photograph, and the artist's rendering. This is a frequent use of the non-verbal language, the representation on paper of the real thing, at least in appearance and description.

A somewhat less visually realistic representation is exemplified by linear perspectives, isometrics and axonometrics, and orthographic views. These devices represent exact shape and dimensional information. The really non-realistic symbolization is exemplified by graphs and curves, flow diagrams, schematics, circuit diagrams, and charts. These uses of the non-verbal languages convey mostly information of relationships and function, but convey them only in a rather approximate way.

It can be seen from this brief examination that the structure of the non-verbal languages is purely spatial--as differentiated from that of the verbal languages which is chronological. This structure is two-dimensional in essence, with some approximation of a third dimension, and even an attempt--usually unsuccessful--to represent a fourth dimension. The increasing use of three dimensional scale models in the profession of technical writing is an interesting phenomenon, by the way.

The functions of both the verbal and non-verbal languages have been discussed; now to some of the significant, limiting factors of the verbal languages. First is the factor of comprehensibility or understandibility. Verbal languages frequently falter in their achieving comprehensibility because of vocabulary and idiomatic difficulties and the consequent possibility of ambiguity or even failure of communication. For instance, we all recognize that the word graphic means drawing; but it also means other things, as indicated by this quotation from Webster's dictionary:

> Graphic: Well delineated; vividly described; of or pertaining to the arts of painting, drawing, engraving, and other arts; of or pertaining to writing or to representation by graphs or diagrams."

It is only the context and the resultant connotation of the word or the symbol that tell the reader which meaning is intended.

A second limiting factor of verbal language is the complexity and density of the structure and organization. We all know the difficulty that is presented, for instance, by a too-long, too-complicated sentence: "Whenever an atom emits an alpha particle it loses an atom of helium and hence its atomic weight is diminished by four units and its chemical valency by two units, the emission of a beta particle causing no change in atomic weight (since the mass of the beta particle is only one seventeen-hundredth of the atom of hydrogen), but the valency increasing by one unit." (This sentence is taken from a well-known encyclopedia.)

We all know the difficulty encountered when we have to read a badly organized paragraph. And we all know the difficulty that is experienced when we read a page or a paper which contains simply too much to be encompassed in the space of time indicated by the printed page.

A third limiting factor of verbal language is its subjectivity. Individual comprehension and reaction toward certain kinds of words and phrases tend to fog the intent of the writer simply because the writer and the reader have not used common techniques or tools to carry the information.

Here is an example of writing which, by its peculiar style, by its subjective reaction on certain readers, becomes foggy. Notice how one's attention is distracted from the primary information of the following letter toward some kind of consideration of what kind of person the writer of the letter could possibly be.

To: Prof. R. A. Sencer
From: John H. Doe

Ref: Paper delivered, TWE Convention
November 15, 1956

The undersigned, unable to attend referenced Convention, requests the kindness of the speaker in providing two (2) copies of referenced paper.

Respectfully yours,

(Facsimile of an actual letter to the author)

The next consideration, in logical sequence, should be whether the non-verbal languages have parallel limitations and/or disadvantages. One of the limitations of the non-verbal languages is that they are almost purely descriptive. This limitation, however, creates for the engineer-reader team an advantage. Engineering drawing, being simple and direct in its function, tends to be easily comprehended (assuming the engineer and the reader have had adequate education in the science). Secondly, the complexity and density of information conveyed on one drawing sheet is limited by the physical size of the presentation. To describe one engineering item, such as a missile, thousands of such drawings with interrelated information may be required. In the verbal languages, however, pages end in the middle of paragraphs, in the midst of presentation of complex ideas, but we simply turn the page. We interrupt with footnotes and definitions and pay no attention to the logical display. The only exception to this is a technique used in journalistic reporting where the reporter makes his page end at some logical break in the continuity of information.

A third combination limitation and advantage of the non-verbal language is the built-in objectivity. Engineering drawing is by nature impersonal. Drawings use universally understood symbolization--at least within subject areas and among graphically sophisticated people--and if there are any doubts, legends are given to explain the symbols. It is only when we leave the fields of engineering, science, technology, that we begin to use little people to represent quantities, that we begin to use cartoon techniques, that we begin to put people into the drawings, that we make drawing personal. A possible exception to this is in architectural drawing where, for some purposes, the architect's personality, his artistic abilities, his techniques may have something to say to the reader.

What does all this amount to? Here are some conclusions we have drawn from these observations and principles. Here is the essence of some of the teaching that goes into a graduate program in technical writing.

1. Over-all description and appearance can be most efficiently presented by drawing or by other techniques in the non-verbal languages.
2. Qualitative statements may be presented by drawings only if the qualities are physical, spatial.
3. Qualities of value and refinement are better presented by words.
4. Relationships may be presented by drawing best when those relationships are spatial. Relationships of kind, of interdependence, of definition and condition are best presented by words.

One final note: Whether the communication is achieved by words or by graphics, it must be kept in focus. We have found, for instance, that the bulk of the writing produced by professional technical writers is produced to describe the nature and function of equipment, devices, apparatus, machines, things. In this kind of writing, the verbal language must follow the non-verbal. Another large proportion of such writing, however, is produced to state the operation, action, movement, manipulation, and control of things. Here the non-verbal must bow to the verbal. In each case, the inherent function of the particular language is the guiding principle for its use. Each language has a job to do and we must know what that job is.

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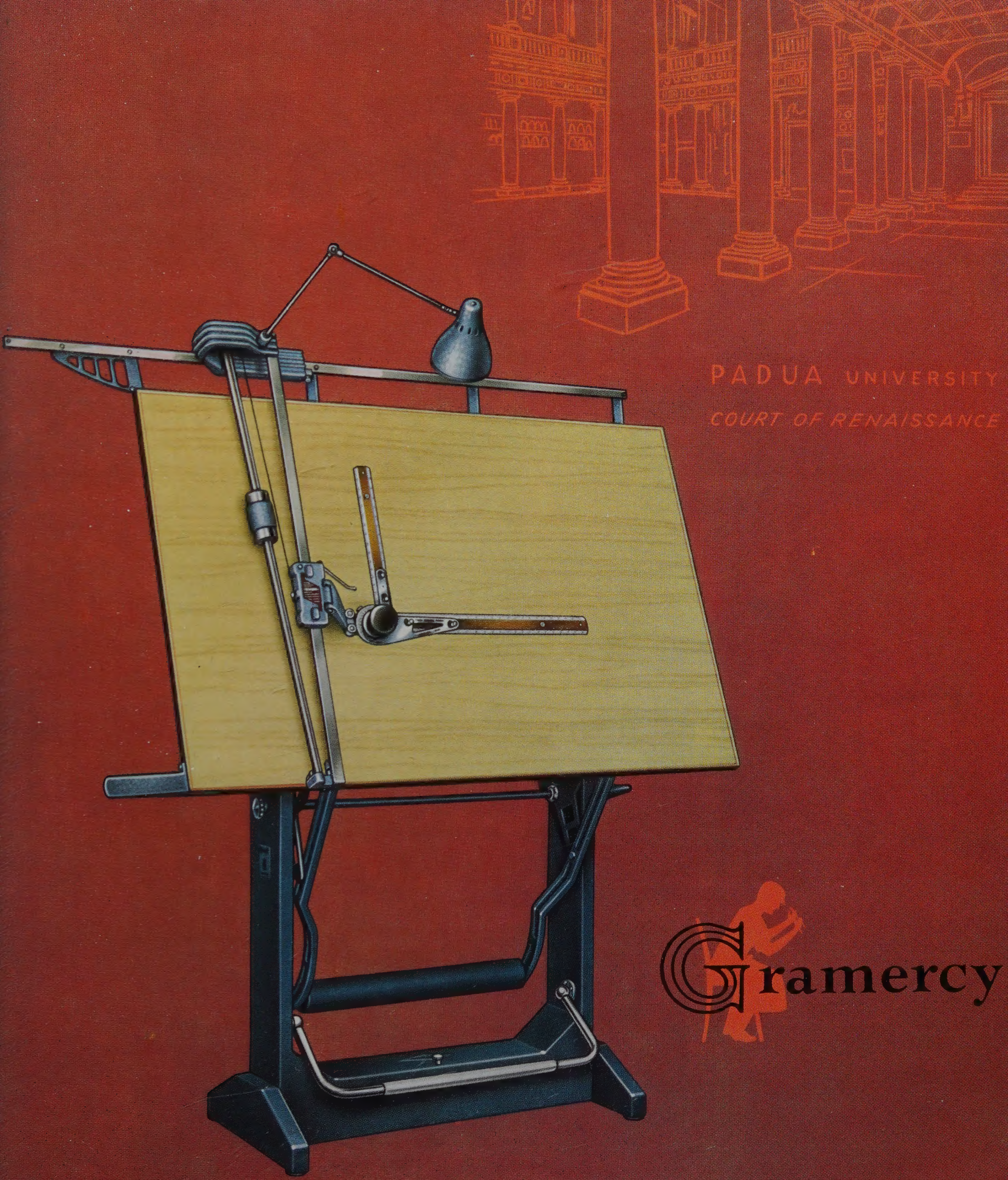

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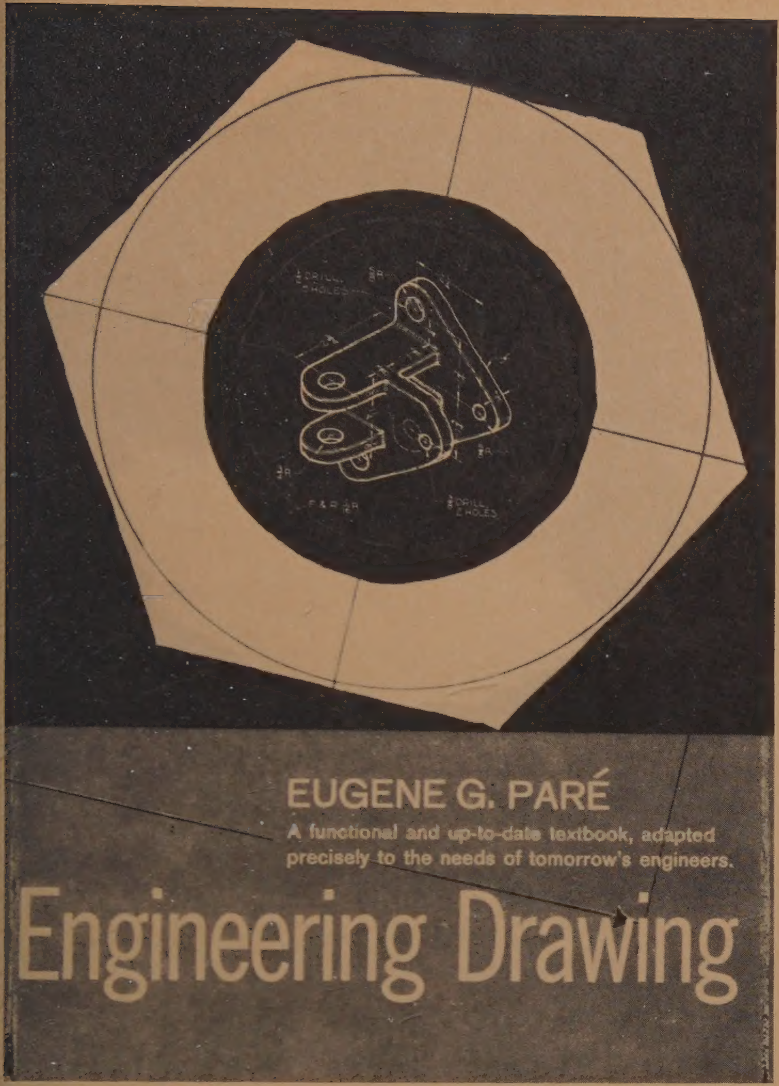

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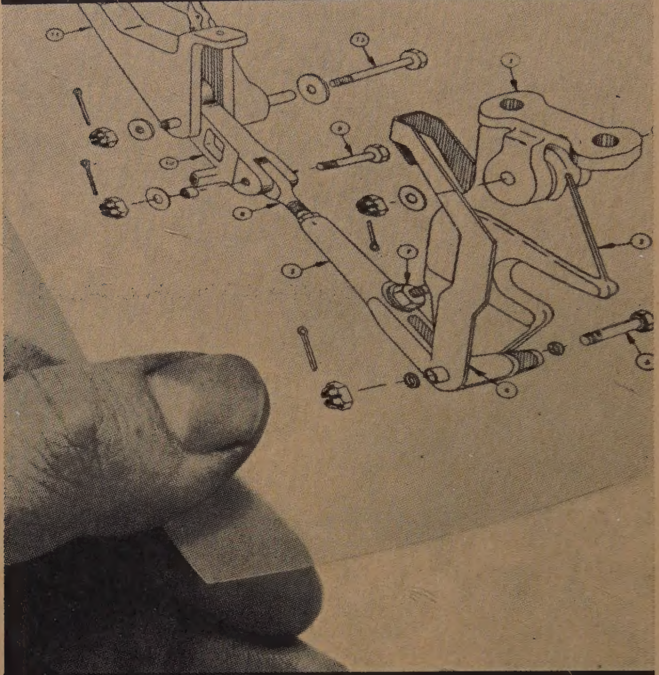

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